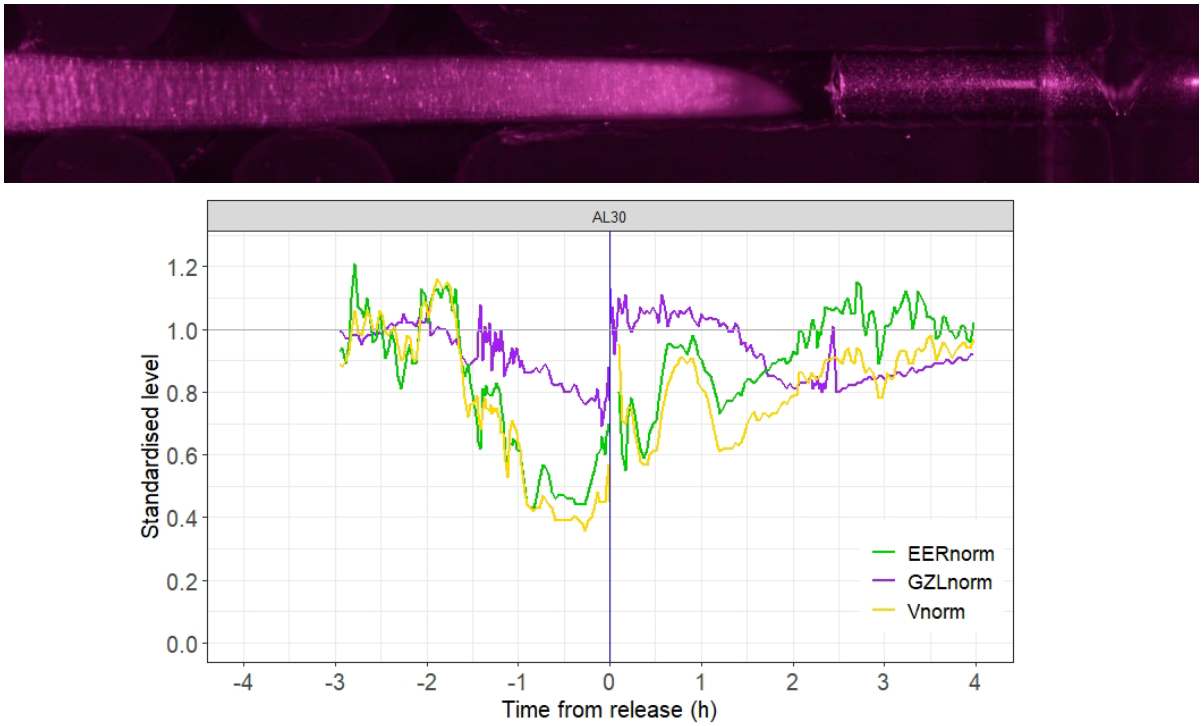
Mecano



Top : Root in the brassing channel just before encountering the obstacle (on the right). Bottom : Dynamics of the standardised root growth rate, maximal relative expansion rate and growth zone length (Vnorm, EERnorm, GZLnorm, respectively) in response to an obstacle (contact at time -1h40) and following the relaxe of the constraint.

Mechanobiological responses of roots to obstacles

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Thematic action concerned: *WP1*

Context —
The root system plays a number of fundamental roles in tree health and ecosystem functioning. Poor rooting due to soil compaction reduces aerial growth and resistance to stress, and can have significant economic repercussions. On a fine scale, the soil is physically heterogeneous and the growing root has to face obstacles of varying size and rigidity. The mechanical stress of the obstacle on the root induces regulations so-called 'mechanobiological' that enable it to continue growing. Understanding these responses is a prerequisite for improving plant rooting in marginal soils.

Objectives —
The overall aim of the Mecano project is to understand the temporal dynamics of biophysical regulations and the molecular pathways underlying the growth response.

Approaches —
Using an experimental set-up designed to block the root with a frontal force while simultaneously measuring the growth and the intensity of the force, we are studying the variations of growth in response to different forces and blocking times, and after the mechanical stress has been removed. We will complete this analysis by determining the kinetics of two biophysical traits involved in cell expansion, osmotic potential and cell wall extensibility.

Key results —
- for the two obstacle stiffnesses tested, the root continued to grow for more than 6 hours, up to forces of 280 mN, i.e. 8.4 bar for a root with a diameter of 0.65 mm.
- The immediate reduction in growth following contact with the obstacle, before the root is significantly loaded (touch response), seems to depend on the stiffness of the obstacle.
- kinematics shows that the reduction in growth rate is due to a sharp reduction in cell expansion, followed by a delayed reduction of the length of the growth zone.
- When the constraint is released, the rate of expansion recovers relatively quickly, but growth remains affected by the reduction of the growth zone length (which reflects the activity of the meristem).

Main conclusions including key points of discussion —
The growth maintenance of a root facing a stress of 8 bar required the regulation of the cell properties that control expansion: the turgor pressure and the rheological properties of the walls. In addition, cell divisions seem more durably affected than cell expansion.
It seems that the reduction in growth depends more on the stiffness of the obstacle than on the stress received, which suggests that the root perceives this stiffness.

Perspectives —
The characterisation of the cell wall properties (in progress) and of the osmotic pressure will provide information on the respective importance of these two levers in enabling the root to continue growing in a hard environment.
Characterisation of the growth response to obstacles of a wider range of stiffness will allow to confirming the perception of stiffness by the root.
The underlying molecular regulations will be studied in a future project.

Valorization —
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- Kong WY, Mosciatti-Jofré A, Quiros M, Bogeat-Triboulot MB, Kolb E and Couturier E. Force generation by a cylindrical cell under stationary osmolytes synthesis. Soumis à Journal of The Royal Society Interface.
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- Leonoff-Noel A, Kolb E, Couturier E, Buré C, Bogeat-Triboulot MB. Séminaire du GDR PHYP, Carry le Rouët, mars 2024. Présentation orale.

Leveraging effect of the project—
National and international collaborations